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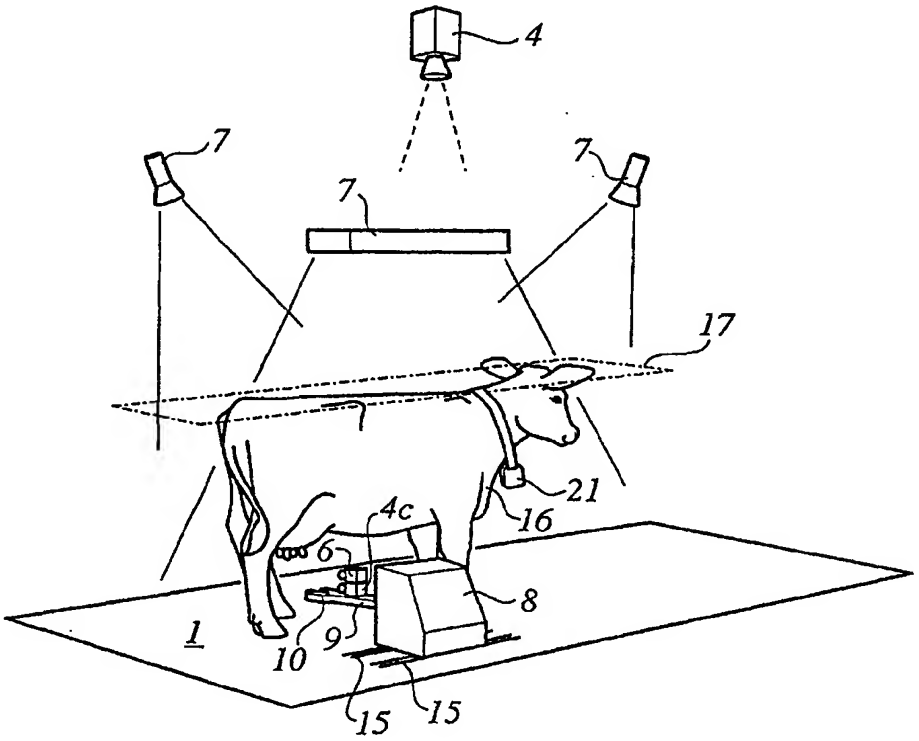
(54) Title: AN APPARATUS AND A METHOD FOR MONITORING AN ANIMAL RELATED AREA

(57) Abstract

An apparatus for determining the length of an animal (16) by monitoring an animal related area (1), comprising an image capturing device (4) arranged on at least one location of said animal related area, said image capturing device being associated with a control means. According to the invention said image capturing device (4) is directed towards an animal (16) having outlines recognisable by said control means adapted to identify the lengths of said animal by eliminating all the background means surrounding said animal.



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An apparatus and a method for monitoring an animal related area

Technical field of the invention

The present invention relates to an apparatus for monitoring an animal related area, comprising an image capturing device arranged on at least one location of said animal related area, said image capturing device being associated with a control means.

It also relates to a method of monitoring an animal related area, comprising an image capturing device arranged on at least one location, said image capturing device being associated with a control means.

Background of the invention

An apparatus and a method for monitoring an animal related area of this kind are known from WO 97/15901, according to which an injured animal having a bleeding wound is recognised by performing colour analysis, such as Red-Green-Blue (RGB) analysis, of an image captured by a video camera.

Also it is known to perform contour analysis of a captured image, see e.g. EP-A1-0 213 660.

Object of the invention

Colour analysis or contour analysis of an image is useful in cases where the colours or contrasts are distinct. However, in a dirty and sparsely illuminated environment, colours and contours tend to be less distinct and are accordingly difficult to analyse.

Therefore, it is an object of the invention to overcome the difficulties of performing analysis of an image captured in an animal related area and to make it possible to determining the length of an animal within said area.

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Summary of the invention

This object has been achieved by an apparatus of the initially defined kind, which is characterised in that said image capturing device is directed towards an animal
10 having outlines recognisable by said control means adapted to identify the lengths of said animal by eliminating all the background means surrounding said animal.

It has also been achieved by a method of the initially defined kind, which is characterised by directing said image capturing device towards an animal having a
15 length recognisable by said control means, and identifying by means of said control means the length of said animal by eliminating all the background means surrounding said animal.

The objects are based on direct definition of the animal. Hereby, a safer and quicker
20 length determination is achieved by image processing. The achieved information may be used for performing different animal related operations, such as teat-cup attachment. Alternatively, other operations, such as feed trough movement towards the head of the animal may be performed.

25 Suitably, possible positions of said length are stored in a memory of the control means, for allowing identification of the real time position thereof.

Preferably, said positions are the front and end positions of the animal identified by said image capturing device. Hereby it is possible to establish a position of said animal.

Preferably, it further comprises an illuminating means associated with said control means. Hereby, image processing may be performed more accurately.

Suitably, said image capturing device is provided with said illuminating means, a viewing direction of said image capturing device being substantially the same as the direction of the light from said illuminating means, said image capturing device having a fixed position and covering a predetermined, restricted animal related area. Hereby, a directed illumination is achieved.

Preferably, said animal is in a position in said animal related area below the image capturing device, said control means including processor means for eliminating all the background means by restricting the captured image comprise a vertical predetermined plane above ground or a floor on which said animal is standing and by restricting the captured image to points determined by the animal outlines. Hereby it is possible to obtain a definite length determination of said animal at a defined height.

Suitably, said horizontal plane is of a predetermined vertical extension depending on the depth of field of the captured image. Hereby it is possible to automatically have a vertical extension by control of the depth of field of the captured image.

Preferably, said predetermined plane height above the ground or the floor is dependent on the size of an animal individual standing on the ground or the floor. Hereby it is the actual size of the animal, which is determining the plane height above the ground or floor.

Suitably, said animal related area is a stall provided with an animal space defining means, such as a fence means, an entrance gate, and a front gate, determining the animal position when said gates are closed, but said space defining means are eliminated from the captured image as belonging to said background means. Hereby it is possible to obtain a firm determination of the animal position.

Preferably, predetermined individual animal length relations are stored in said memory of said control means for a rough determination of the position of a cow's udder or teats, said control means controlling a milking robot, having a robot arm movable into said animal related area. Hereby is achieved a possibility to make a rough determination of important positions at the animal body.

Suitably, a teat locating device is fixed at the robot arm for locating of a teat position outgoing from the determined position of the udder. Hereby a precision adjustment is obtained with respect to important positions at the animal body.

Preferably said control means in response to interpretation of said captured image allows for a tracking action to take place for controlling of the robot arm to follow animal movements within said animal related area. Hereby a tracking action is obtained making it possible to follow unpredictable animal movements.

Suitably, said locating device includes a local image capturing device, preferably assisted by a local illuminating means, such as a halogen lamp or source of structural light. Hereby the precision adjustment is facilitated.

Preferably, said image capturing device is a video camera or an IR-camera or a digital camera. Hereby electrical signals are generated in an analogous or digital form to be directly used by said control means being of electronic processor kind.

Suitably, an identification means is worn by said animal, said identification means being in information connection with said control means for identification of the animal arriving at or standing in said animal related area. Hereby the actual animal may be identified, which is important when comparing stored individual animal data to actual data obtained from the captured images.

Preferably, said identification means is a transponder worn by said animal, and is in wireless connection with a transponder receiver, said transponder receiver being connected to said control means. Hereby no cable installation is necessary.

Suitably, said identification information obtained from said identification means are used to activate length reference data individually stored in said memory of the control means for every animal able to be found at the animal related area, a comparator means then being able to compare the length reference data to length data obtained by the image capturing device. Hereby an automatic activation of the system is obtained.

Preferably, said control means in response to signals received from said image capturing devices is arranged for homing of said robot arm and any supported apparatus, such as teat-cups, cleaning devices, following up treatment apparatus, etc., to the animal's udder. Hereby the robot arm as well as apparatuses carried thereof is controllable in a favourable manner.

Suitably, movements of teat-cups carried by said robot arm are controlled by said control means to be applied to respective one of the animal's teats. Hereby, full automation of a milking robot is possible.

Preferably, cleaning devices, such as brushes and spraying means carried by said robot arm, are controlled by said control means for cleaning of the animal's teats. Hereby also the animal treatment before as well as after the milking procedure is obtained in an automatically manner.

Drawing summary

The invention will now be described in more detail with reference to the accompanying drawings, in which

Fig 1 illustrates an embodiment of the invention, including a cow and a milking robot;

Fig 2 illustrates a top view of the embodiment shown in Figure 1; and

Fig 3 illustrates a block diagram for processing electric signals generated by an image capturing device to controlling a milking robot according to the invention.

Fig 1 and 2 illustrate a cow 16 standing on the floor or ground defining an animal related area 1.

Detailed description

An image capturing device 4, such as one or several video cameras, IR-cameras or digital cameras producing analogous or digital output signals, is arranged above the cow 16, e.g. on the ceiling of an animal shed, and having a vertical or somewhat inclined observation direction to the floor or ground 1. The image capturing device 4 is mounted in a fixed position with respect to a gateway 24 and/or 25 or another reference point at the floor or ground.

The image capturing device 4 is provided with a wide angle or a zoom lens.

One or more illuminating means 7 are provided for illumination of the cow 16. The illuminating means 7 may be in form of fluorescent lamps, halogen lamps, traditional light bulbs, sources of IR-light or structured light - such as laser - forming light stripes, arranged above the cow 16 but out of the camera field of view. The illuminating means 7 may be continuously lit or, if preferred, lit by a movement detector (not shown) or by the image capturing device 4 when detecting a movement in its field of view.

The image capturing device 4 as well as the illuminating means 7 are electrically connected to a control means 11, shown and described more in detail below with reference to Fig 3.

The animal related area 1 shown in Figure 1 is an animal stall for milking a cow 16 by means of a milking robot 8 with a robot arm 9, a gripper 10 for gripping a teat cleaning means, a teat-cup or the like, provided for performing teat cleaning, milking, etc. The milking robot 8 is movable along a track 15 and is associated with the control means 11 (Fig 3) to be positioned in alignment with the udder of the cow 16. A wall or a fence 23 and further limitations, such as an entrance gate 24 and a front gate 25 define the stall. The defining means 23, 24, 25 determine the animal position when the gates are closed. However, the defining means 23, 24, 25 are eliminated from the captured image as belonging to background means being unimportant when processing the captured images for determining the animal length.

A further image capturing device 4' with optional illuminating means 6 is arranged on the robot arm 9 to view the udder of the cow 16. Accordingly, the milking robot

8 operates in response to the different image capturing devices 4, 4'. Though it may be preferable to arrange illuminating means 7 as light sources in addition or as alternative to the illuminating means 6, it should be noted that neither of them are necessary during normal light conditions, as cameras of today are highly light sensitive.

Furthermore it should be noted that it is not necessary to utilise all image capturing devices 4, 4' together. As an example, the image capturing device 4 may be utilised together with a teat locating means of another kind than described above, such as a laser sensor or an ultrasonic sensor.

As indicated above, the image capturing device 4 as well as the illuminating means 7 are electrically connected to a control means 11 as shown in Figure 3, illustrating a block diagram of processing the signals generated by said image capturing device 4 for controlling the milking robot 8.

The position of the camera 4 may be used as a room reference for the image analysis to be performed according to the invention.

The control means 11 comprises a memory 12, a comparator 13 and a processor 14. As indicated by doubled arrow connections within the control means 11 the memory 12, the comparator 13 and the processor 14 communicate with each other in both directions in a manner known per se.

Also the information communication with the robot 8 is of the two way type taking care of the information generated by the image capturing device 4' at the robot arm 9 (Fig 1 and 2) and, in the opposite direction, for controlling the robot 8 to make a safe and correct performance of teat cleaning, milking, etc.

The image capturing device 4 and the illuminating means 7, however, are electrically connected to the control means 11 in a one way fashion. Thus, the image capturing device 4 provides the control means 11 with signals from the captured image to be processed and the control means 11 controls the illuminating means 7 to be put on and off.

Operation

The presence of an animal 16 in the animal related area 1 covered by image capturing device 4 is established either by a movement detector (not shown) or by the said image capturing device 4 as such.

The control means 11 is designed to process the signals received from the image capturing device 4 in such a way that all the background means 23, 24, 25 around and below the animal 16 are eliminated. Favourably, also the captured image signals from the image capturing device 4 are cleared of details above and below a predetermined height from the floor or ground surface 1. Thus, the animal 16 is viewed by the control means 11 as a simple sheet in a vertical predetermined plane, e.g. at the animal back height (say within the height of 1,6 - 2,2 m from the floor surface on which the animal 16 is standing). Such a plane is indicated by the reference 17 in Fig 1 and may correspond to the outline 18 of the animal 16 shown in Fig 2.

By defining the captured image as a simple sheet, the image of the animal 16 has definite front and end points 19 and 20, respectively, shown in Fig 2. Thus, by the control means 11 and the processor 14 therein, it is easy to obtain the length 19-20 of the animal 16.

Having stored in the memory 12 information on the normal length of the animal in question, and on important positions at the body of said animal, such as the udder or teats of the cow, the control means 11 may be used to provide control signals for the milking robot 8 to take a position along the track 15 in line with the important positions of the animal 16. Further control signals for the milking robot 8 are obtained from the further image capturing device 4' for directing the robot arm 9 in a correct position to perform the actual work. The further control signals may be processed by the processor 14 and returned to the milking robot 8 or are directly used by the milking robot 8 without any processing in the control means 11.

Thus, predetermined length relations of an animal 16 may be stored in the memory 12 of the control means 11 for a rough determination of a position at the body of the animal, such as the udder or teats of a cow. The stored predetermined length relations being then compared in a comparator means 13 to length information 19-20 obtained from the image capturing device 4. Resulting signals are processed by processor means 14 supplying control signals to the robot 8 for moving the robot arm 9 into and out from the animal related area 1.

By the control means 11 also a tracking action is executed for following the animal's 16 movement within said animal related area 1. Thus, the animal's 16 movements are responded to by corresponding movements of the robot arm 9 controlled by the control means 11.

Alternatively, tracking may be performed by subtraction of an image from an image at a previous instant. By comparison of the images, the relative movement of the animal is established.

For obtaining a length determination method connected individually to each animal 16 the method includes following steps:

- a transponder signal from the transponder 21 is received by a transponder receiver 22 acting on said control means 11 for identification of the actual animal 16 arriving at and/or standing within said animal related area 1;
- an image defining signal from said image capturing device 4 is received by said control means 11 evaluating said image defining signal with respect to the length 19-20 of said animal 16;
- said transponder signal acting on said control means 11 to supply length reference information for the actual animal from said memory means 12 to a comparator means 13 also receiving said image defining signal;
- the comparator output signal being processed in a processor means 14 also obtaining monitoring signals from a milking robot 8 to be controlled by said control means 11;
- control signals being supplied from said control means 11 to said milking robot 8 in response to said animal length 19-20 and to animal movements within said animal related area 1.

By the method according to the present invention the robot arm 9 is controlled to be homed to the animal's 16 udder or teats as a response to signals received from the image capturing device or devices 4 and/or 4' and processed by the control means 11.

The apparatuses carried or supported by the robot arm 9 are put in correct position to the animal 16 for performing a work aimed at. For instance, teat-cups carried by the robot arm 9 are applied to respective one of the animal's 16 teats in response to control signals from the control device 11. In a similar way cleaning and following up treatment before and after the milking action may be controlled according to the method of the present invention.

It should be understood that the animal related area 1 could be arranged outdoors, rather than in an animal shed. It should furthermore be noted that the rails 15 are not necessary for achieving the object of the invention. Instead (or in addition), the robot arm 9 may be movable about a vertical axis.

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The described apparatus and method are applicable to all animal related areas where animals to be milked are to be monitored, such as cows, sheep, goats, buffaloes and horses.

Claims

1. An apparatus for monitoring an animal related area (1), comprising at least one image capturing device (4) arranged on at least one location of said animal related area, said image capturing device being associated with a control means (11),

characterised in that

said image capturing device (4) is directed towards an animal (16) having outlines (18) recognisable by said control means (11) adapted to identify a length (19-20) of said animal by eliminating all the background means surrounding said animal;

predetermined individual animal length relations are stored in a memory (12) of said control means (11) for a rough determination of the position of a cow's udder or teats; and

said control means (11) controls a milking robot (8), having a robot arm (9) movable into said animal related area (1).

2. An apparatus according to claim 1, **characterised in that**

possible positions of said length (19-20) are stored in said memory (12) of the control means (11), for allowing identification of the real time position thereof.

3. An apparatus according to claim 1 or 2, **characterised in that**

said positions are the front (19) and end (20) positions of the animal (16) identified by said image capturing device (4).

4. An apparatus according to anyone of the preceding claims, **characterised in that** it further comprises

an illuminating means (7) associated with said control means (11).

5. An apparatus according to claim 4, **characterised in that**

said image capturing device (4) is provided with said illuminating means (7);

a viewing direction of said image capturing device being substantially the same as the direction of the light from said illuminating means; and

said image capturing device having a fixed position and covering a predetermined, restricted animal related area (1).

6. An apparatus according to anyone of the preceding claims, **characterised in that**

said animal (16) is in a position in said animal related area (1) below the image capturing device (4);

said control means (11) including processor means (14) for eliminating all the background means by restricting the captured image comprise a horizontal plane (17) at a vertical height above ground or a floor on which said animal is standing and by restricting the captured image to points (19, 20) determined by the animal outlines (18).

7. An apparatus according to claim 6, **characterised in that**

said horizontal plane (17) is of a predetermined vertical extension depending on the depth of field of the captured image.

8. An apparatus according to claim 6 or 7, **characterised in that**

said predetermined plane height above the ground or the floor is dependent on the size of an animal individual (16) standing on the ground or the floor.

9. An apparatus according to anyone of the preceding claims, **characterised in that**

said animal related area (1) is a stall provided with an animal space defining means, such as a fence means (23), an entrance gate (24), and a front gate (25), determining the animal position when said gates are closed, but said space defining means are eliminated from the captured image as belonging to said background means.

10. An apparatus according to anyone of the preceding claims, **characterised in that**

a teat locating device (4') is fixed at the robot arm (9) for locating a teat position outgoing from the determined position of the udder.

11. An apparatus according to anyone of the preceding claims, **characterised in that**

said control means (11) in response to interpretation of said captured image allows for a tracking action to take place for controlling of the robot arm (9) to follow animal movements within said animal related area (1).

12. An apparatus according to claim 10, **characterised in that**

said locating device includes a local image capturing device (4'), preferably assisted by a local illuminating means (6), such as a halogen lamp or source of structural light.

13. An apparatus according to anyone of the preceding claims, **characterised in that**

each one of said image capturing devices (4, 4') is a video camera or an IR-camera or a digital camera.

14. An apparatus according to anyone of the preceding claims, **characterised in that**

an identification means (21) is worn by said animal (16); and

said identification means (21) being in information connection with said control means (11) for identification of the animal arriving at or standing in said animal related area (1).

15. An apparatus according to claim 14, **characterised in that**

said identification means (21) is a transponder worn by said animal (16) in wireless connection to a transponder receiver (22); and

said transponder receiver being connected to said control means (11).

16. An apparatus according to claim 14 or 15, **characterised in that**

said identification information obtained from said identification means (21) is used to activate length reference data individually stored in said memory (12) of the control means (11) for every animal (16), which can to be found at the animal related area (1); and

a comparator means (13) then being able to compare the length reference data to length data obtained by the image capturing device (4).

17. An apparatus according to anyone of the preceding claims, **characterised in that**

said control means (11) is arranged for homing of said robot arm (9) and any supported apparatus, such as teat-cups, cleaning devices, following up treatment apparatus, etc., to the animal's (16) udder in response to signals received from said image capturing devices (4, 4').

18. An apparatus according to claim 17, **characterised in that**

movements of teat-cups carried by said robot arm (9) are controlled by

said control means (11) to be applied to respective one of the animal's (16) teats.

19. An apparatus according to claim 17, **characterised in that**

cleaning devices, such as brushes and spraying means carried by said robot arm (9), are controlled by said control means (11) for cleaning of the animal's (16) teats.

20. A method for determining the length of an animal (16) by monitoring an animal related area (1), comprising an image capturing device (4) arranged on at least one location, said image capturing device being associated with a control means (11),

characterised by

directing said image capturing device (4) towards an animal (16) having outlines (18) recognisable by said control means (11); and

identifying by means of said control means (11) a length (19-20) of said animal by eliminating all the background means surrounding said animal.

21. A method according to claim 20, **characterised by**

storing in said memory (12) possible positions of said length (19-20) for allowing identification of the real time position thereof.

22. A method according to anyone of claims 20 and 21, **characterised by**

identification of said positions as the front (19) and end (20) positions of said animal (16).

23. A method according to anyone of claims 20 to 22, **characterised by**

illuminating said animal (16) by means of an illuminating means (7) associated with said control means (11).

24. A method according to anyone of claims 20 to 23, **characterised by**

processing of the captured image for eliminating of all the background means by restriction of said captured image to a horizontal predetermined plane (17) at a vertical height above ground or a floor (1) on which said animal (16) is standing; and

restricting said captured image to points (19, 20) determined by outlines (18) of said animal.

25. A method according to anyone of claims 20 to 24, **characterised by**

storing of predetermined length relations of said animal (16) for rough determination of a position at the body of said animal, such as the udder or teats of a cow; and

said predetermined length relations stored in a memory (12) being compared to said length information obtained from said image capturing device (4) for having an output signal from said control means (11) controlling a milking robot (8) having a robot arm (9) movable into said animal related area (1).

26. A method according to anyone of claims 20 to 25, **characterised by**

a tracking action executed by the control means (11) in response to the image interpretation in such a way that the animal's (16) movement within said animal related area (1) is responded to by corresponding movement of said robot arm (9) controlled by said control means.

27. A method according to anyone of the claims 20 to 26, **characterised by** the following steps:

a transponder signal (from 21) is received by a transponder receiver (22) acting on said control means (11) for identification of the actual animal (16) arriving at and/or standing within said animal related area (1);

an image defining signal (from 4) is received by said control means (11) evaluating said image defining signal with respect to the length (19-20) of said animal (16);

said transponder signal acting on said control means (11) to supply length reference information for the actual animal (16) from said memory means (12) to a comparator means (13) also receiving said image defining signal;

the comparator output signal being processed in a processor means (14) also obtaining monitoring signals from a milking robot (8) to be controlled by said control means (11); and

control signals being supplied from said control means (11) to said milking robot (8) in response to said animal length (19-20) and to animal movements within said animal related area (1).

28. A method according to anyone of the claims 20 to 27, **characterised in that**

identification information obtained from said identification means or transponder (21) is activating length reference data individually stored in said memory (12) of the control means (11) for every animal (16) able to arrive at said animal related area (1); and

the activated length reference data being compared to length data applied from said image capturing device (4).

29. A method according to anyone of the claims 20 to 28, **characterised in that**

homing of said robot arm (9) and any apparatus, such as teat-cups, cleaning devices, following up treatment apparatus, etc., supported thereof, to the animal's (16) udder or teats as a response to signals received from said image capturing devices (4. 4') and processed by said control means (11).

30. A method according to claim 29, **characterised by**

applying of teat-cups, carried by said robot arm (9), to respective one of

the animal's (16) teats in response to control signals from said control means (11).

31. A method according to claim 29, **characterised by**

cleaning of the animal's (16) teats by cleaning devices carried by said robot arm (9) in response to control signals from said control means (11).

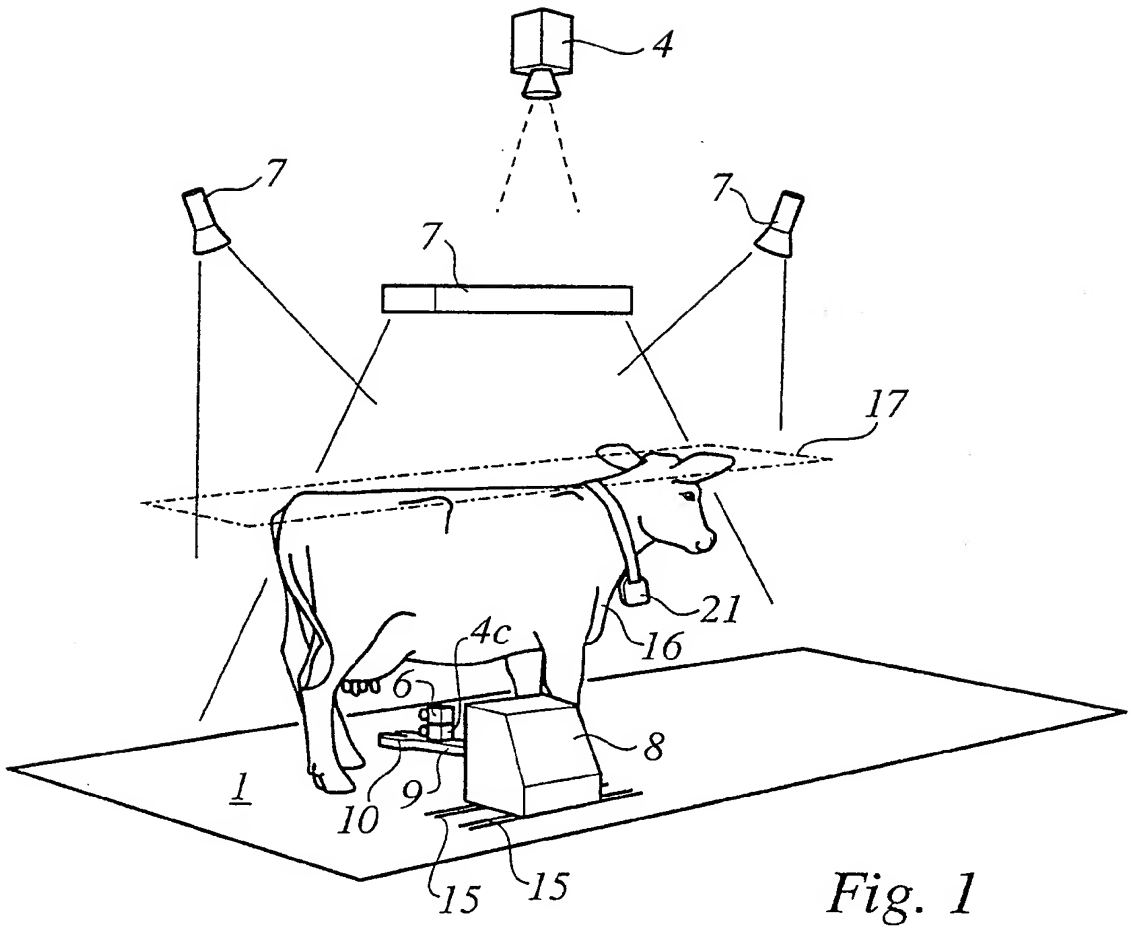

Fig. 1

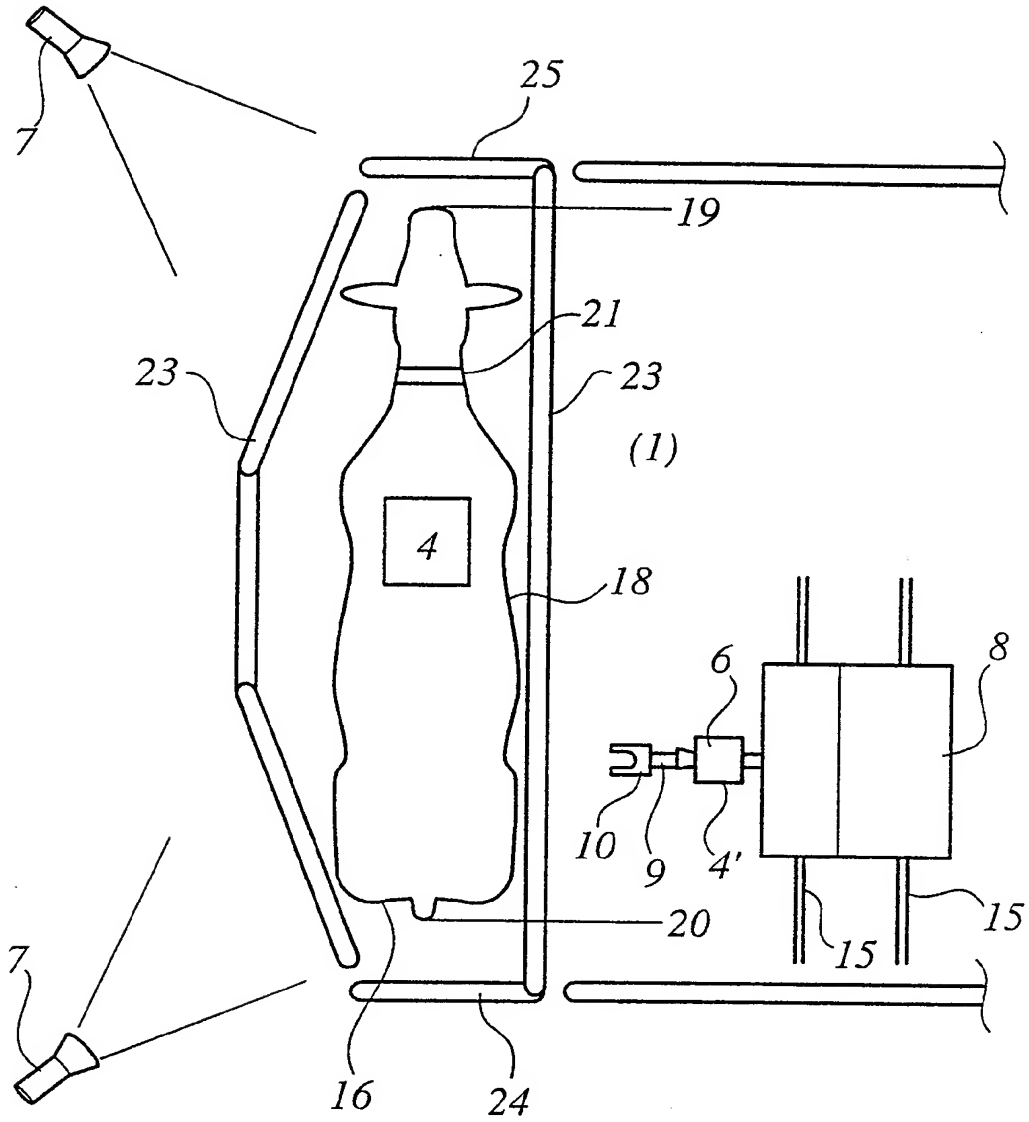

Fig. 2

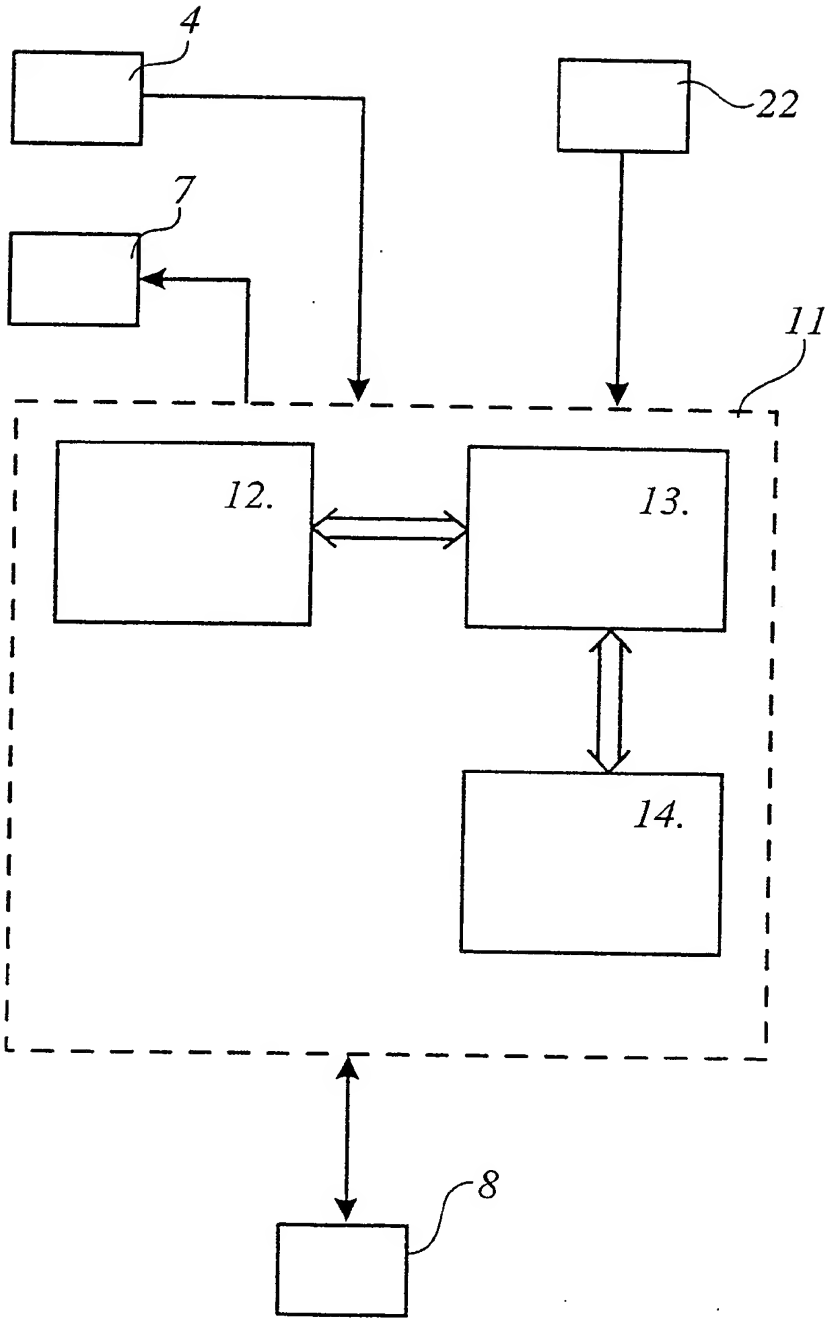

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/01491

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: A01K 11/00, A01J 5/017
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: A01J, A01K, B25J, G06T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9114180 A1 (AUSTRALIAN MEAT & LIVESTOCK RESEARCH & DEVELOPMENT CORPORATION), 19 Sept 1991 (19.09.91), page 17, line 7 - line 30; page 19, line 31 - page 20, line 11, abstract	1-5,9,13-15, 20-23
Y		10-12,14-15, 17-19,25-26, 29-31
A		6-8,16,24, 27,28
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Y	WO 9715900 A1 (ALFA LAVAL AGRI AB), 1 May 1997 (01.05.97), page 8, line 9 - line 14, claims 1, 26-30	10-12,17-19, 25-26,29-31
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 February 2000	12 -02- 2000
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Patrik Blidefalk/AE Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/01491

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	NL 9200095 A (VAN DER LELY NV C) 1993-08-16 (abstract) World Patents Index (online). London, U.K.: Derwent Publications, Ltd. (retrieved on 1999-05-07). Retrieved from: EPO WPI Database. DW9336, Accession No.93-285894	14-15
A	--	10,16,21,25, 27,28
A	US 5631976 A (R.M. BOLLE ET AL.), 20 May 1997 (20.05.97), abstract	1-31
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A	US 5034986 A (K-P KARMANN ET AL.), 23 July 1991 (23.07.91), abstract	11,26
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INTERNATIONAL SEARCH REPORT

Information on patent family members

02/12/99

International application No.
PCT/SE 99/01491

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